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Progress of Queenston-Chipp wa Power Canal

Reprint from *The Canadian Engineer*
August 28th, 1919, issue

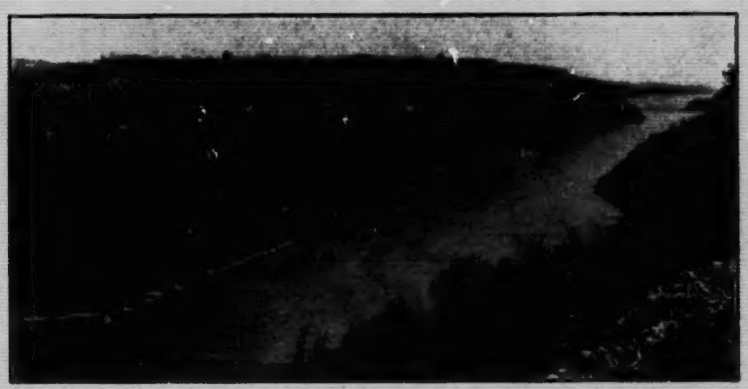
ONTARIO ARCHIVES TORONTO

Progress of Queenston-Chippawa Power Canal

Nearly Five Million Cubic Yards of Earth and Rock Removed—Huge Shovel Establishes Record in Loading 8,500 Cubic Yards on Cars in 20 Hours—Extensive Construction Railway Handling 200 Trains Daily—Payroll Only 1,000 Men Per Shift—Construction Equipment Worth Several Million Dollars

WITH several million dollars' worth of equipment on the job, and a pay roll of 2,000 men, the Hydro-Electric Power Commission of Ontario is making rapid progress on the Queenston-Chippawa power development. The construction organization has been perfected, any probable difficulties in excavation have been adequately met, the overburden has been stripped from nearly half the length of the canal, considerable rock has been taken out, the forebay is nearing completion, the power house site has been cleared, the construction railway into the power house site is being operated, the hydraulic turbines and the generators are under construction; in brief, it is now almost solely a matter of digging, channeling, drilling and blasting to complete what will probably be the largest and one of the most efficient hydro-electric plants in the world, developing at least 300,000 h.p. under 305 ft. average net head.

In the June 20th, 1918, issue of *The Canadian Engineer*, pages 545 to 550 inclusive, appeared an article which dealt with the economics and design of this development. In the September 26th and November 21st, 1918, issues respectively appeared brief descriptions of the proposed turbines and generators. The present article is intended primarily to deal with the methods of construction and the progress that has been made to date.



POWER-HOUSE SITE CLEARED—VIEW FROM THE UNITED STATES BANK OF THE NIAGARA RIVER—LEWISTON BRIDGE, ABOUT A MILE DOWNSTREAM, CAN BE SEEN AT EXTREME RIGHT OF PHOTO

Referring to the accompanying profile, it will be noted that the canal is entirely in rock excepting from about Sta. 235 to Sta. 350, near the Whirlpool, and from Sta. 0 to Sta. 40, adjacent to the Welland river.

From Sta. 2[illegible] (Niagara, St. Catharines & Thorold Railway) to Sta. 460 (the forebay) the canal section has been entirely stripped to rock with the exception of a small amount of work remaining to be done near the Whirlpool gully. Three electrically-driven shovels are at work removing the overburden between Sta. 100 and Sta. 273. With the exception of pilot cuts, practically no earth has been moved between the Welland river and Sta. 200. Rapid progress is being made with the Welland river section of the work, which is being handled by a dredge and a cableway excavator.

A large quantity of rock has been removed at the forebay and between the forebay and Sta. 273.

There are ten power shovels at work on the canal, all manufactured by the Bucyrus Co. The three largest are electrically-driven, each being equipped with an 8 cu. yd. bucket for excavation in earth, and each weighing 400 tons. There are also three electrically-driven shovels each equipped with buckets of 4½ cu. yds. capacity, and one electrically-driven shovel (with caterpillar traction) equipped with a ¾-yd. bucket. There are three steam shovels, one having a bucket of 2 yds. capacity, one 1-yd. and one ¾-yd., the latter two having caterpillar traction.

An 8-yd. shovel is at work at the forebay removing the rock to a depth of about 45 ft. The first lift of rock has been entirely removed to a width of 300 ft. at the gate house and the remainder of the rock to the necessary depth has been drilled and blasted to a total width of 500 ft. at the gate-house and is now being loaded by the shovel. Tracks have been laid on top of the blasted rock, at an elevation about 30 ft. above the shovel's tracks, and the electrically-hauled trains of dump cars are run over the rock directly to the shovel.

Between the forebay and Sta. 273, two other shovels are working in rock, one 8-yd. and one 4½-yd. capacity. It should be stated that these capacities, as well as those mentioned above, are the capacities of these shovels in earth. The capacities in rock are, of course, proportionately smaller. For example, each 8-yd. shovel has a capacity of 5½ cu. yds. in rock.

The two shovels that are working in rock between the forebay and Sta. 273, started at Station 295 and are going in opposite directions, the big one working toward the Welland river and the 4½-yd. shovel going toward the forebay, both working on the first lift of rock.

Channeling, drilling and blasting proceeds almost incessantly, day and night, ahead of the shovels. The shovels are being operated by two shifts of ten hours each, an adequate equipment of flood lamps providing plenty of illumination for carrying on the work at night.

A 4½-yd. shovel is at work at the Whirlpool cleaning up the bottom preparatory to the riprap construction.

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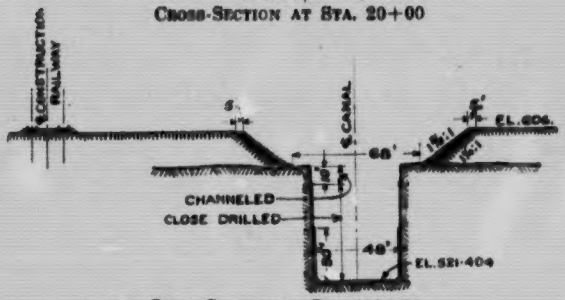

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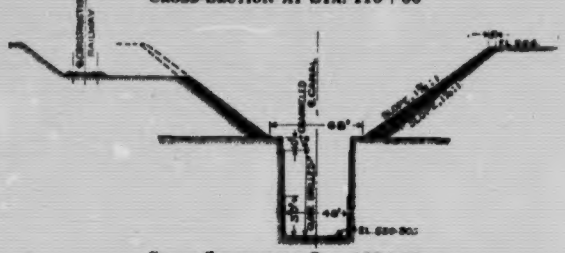

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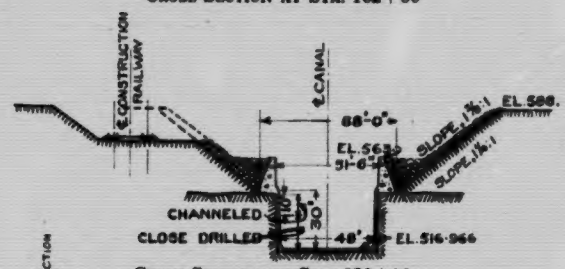

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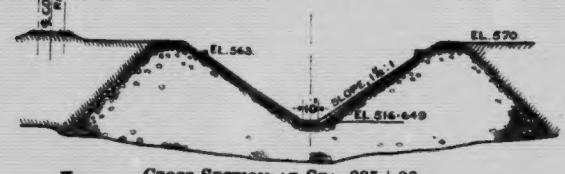

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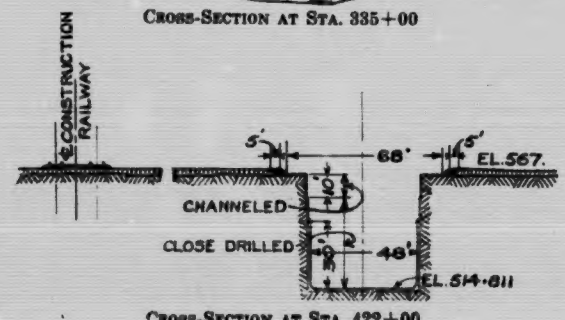


CROSS-SECTION AT STA. 422+00

The 1-yd. shovel is working toward the Welland river, south of Sta. 323 (the Grand Trunk bridge), cleaning the rock preparatory to channeling.

Between the Niagara, St. Catharines & Thorold Railway (Sta. 273) and Muddy Run creek (Sta. 200), there are

BATTERY OF RAND AND SULLIVAN ROCK DRILLS AT THE FOREBAY

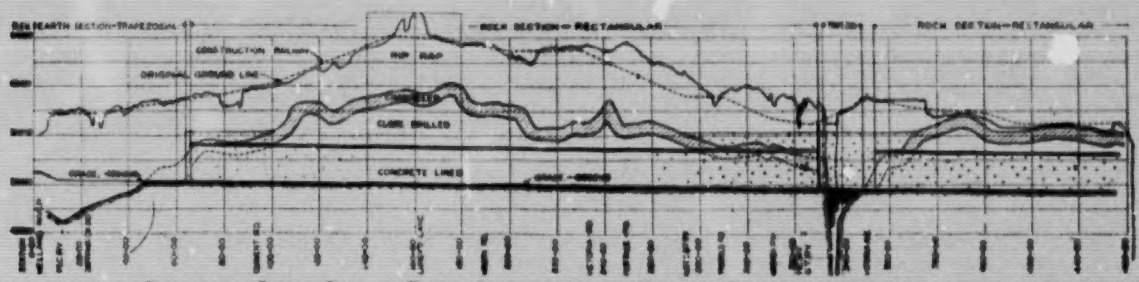
three shovels working in earth: One 8-yd. shovel, one 4½-yd. and one 2-yd.

The steam-driven ⅝-yd. shovel is working south of Muddy Run, digging pilot cuts, ditching, loading, ballasting and doing other miscellaneous preparatory work. The electrically-driven ⅝-yd. shovel is grading the construction railway from Queenston to the power-house site.

Among the other plant on the job are 21 electric locomotives, 7 steam locomotives, 150 twenty-yard Western steel dump cars, 50 sixteen-yard Western wooden dump cars, 12 box and flat cars, one 5-yd. dredge, one Ligerwood cableway excavator (800-ft. span), 2 draglines each equipped with a

CRANE MOVING ROCK IN SKIPS FROM CANAL SECTION AT ENTRANCE TO FOREBAY

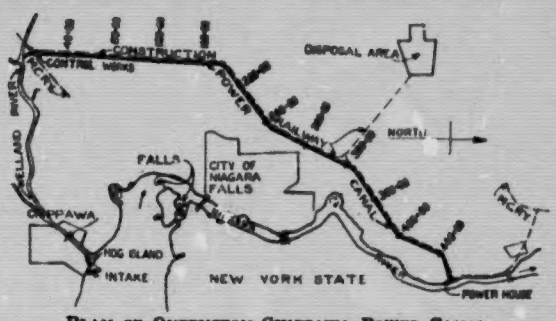
one-yd. bucket, 2 White motor dump trucks, 1 Sawyer-Massey traction engine, 10 Troy 3-yd. dump wagons, 1 Sawyer-Massey road scraper, 3 Bay City cranes of 40-tons capacity at 16½ ft. radius, 2 Bay City cranes of 15 tons capacity at 16½ ft. radius, 2 London concrete mixers, 4 Ransome concrete mixers, 1 Wettlauffer concrete mixer (each of these 7 mixers having a capacity of approximately 1 cu. yd. of mixed concrete), 2 cement-guns of the N-2 type, 1 Ransome grout mixer, 1 McKenna bar bender, several Sterling concrete carts, 1 Stephens-Adamson crushed stone conveyer, 75 Sullivan rock drills, 8 Ingersoll-Rand rock drills, 2 Leyner oil furnaces, 3 Sullivan drill sharpeners, 1 McKiernan-Terry pile hammer, 1 Vulcan pile hammer, 1 Beatty clam-shell bucket, 1 Hayward orange-peel bucket, 1 Orton & Steinbrenner ⅝-yd.



PROFILE ON CENTRE LINE OF POWER CANAL FROM THE WELLAND RIVER TO THE NIAGARA RIVER

bucket, 1 Hayward 1½-yd. clam-shell bucket (motor driven), 1 Andresen-Evans 3-yd. bucket (on cableway excavator), 12 Sullivan channellers, 1 McCully No. 5 gyratory crusher, 2 McCully No. 6 gyratory crushers, 1 McCully No. 7½ gyratory crusher, 2 Barber-Green 60-ft. portable conveyors, 1 Traylor 60-in. by 84-in. steel jaw crusher, 36 thousand-watt Davis flood lamps, 13 four-hundred-watt Lyman flood lamps, 2 Napanee hoists, 1 Ligerwood hoist, 1 Beatty hoist, 2 Jordan spreaders, 2 Imperial tie tampers, 1 double-track snow plow built by Canadian Steel Foundries, numerous Herbert Morris hoists, 2 Lincoln track bonders, numerous Norton Jacks and a large quantity of valves, hydrants, pipe, tanks, standpipes, searchlights, transformers, motors, etc. There are about 36 pumps of various types and capacities, a few of which are operated continuously, the others being held for emergencies and intermittent use.

The job is equipped with its own telephone system, which also is connected by private wire direct to the head office of the Hydro-Electric Power Commission in Toronto, and with its own water distribution system and electric light system.



PLAN OF QUEENSTON-CHIPPAWA POWER CANAL

Fifty-five miles of construction railway have been built, including yards, sidings, etc. The 2½ miles of railway from the canal to the disposal area is one of the busiest double track lines in America, carrying from 180 to 200 trains (of ten cars each) daily during the 20 working hours. A despatching system, controlled by telephone, has been found necessary, especially at night.

In the Whirlpool yards are located a large machine shop, store houses, cement stores, forges, etc. The list of equipment above mentioned does not include the many machine tools, trip-hammers, wood-working machines, welding outfits, etc., with which these buildings are equipped nor the thousand and one items with which the store-houses are filled to the roofs in orderly bins and racks, including everything that might possibly be needed, from safety pins and iodine to dynamite and structural steel.

The main transformer house is at station 320. Here are installed 12 Sullivan air compressors, each having a capacity of 1,000 cu. ft. per minute against 125 lbs. pressure. The installed transformer capacity at the station is about 7,500 k.v.a., of which 3,000 k.w. is direct current.

Another transformer house is being erected at Sta. 90. A small transformer house was erected near Chippawa at the beginning of the work for the purpose of supplying the Welland river section. All power is obtained from the Ontario Power Co., which is now controlled by the Hydro-Electric Power Commission. The compressed air is used for operating the drills and channellers and for numerous small tools. It is piped in double 8-in. and single 10-in. lines, with valves every 500 ft.

The first shovel on the job was the 2-yd. Atlantic type shovel, which began work in the spring of 1917 at Sta. 324. Since then there has been removed to date a total of a little more than 4,000,000 cu. yds. of earth and 500,000 cu. yds. of rock. The excavating plant has been increased continuously, two of the largest shovels having been received only a few months ago, and the work is now progressing 50% faster than previously. Since January 1st, 1919, approximately 2,200,000 cu. yds. of earth and 350,000 cu. yds. of rock have been removed, partly by the dredge, partly by the cableway excavator and partly by miscellaneous equipment, but mostly by the shovels.

The best day's record for any one shovel was the loading of 420 cars in two 10 hr. shifts, this being equivalent to 8,500 cu. yds. bank measurement.

The total amount of material to be excavated from the canal section is 9,000,000 cu. yds. of earth and 4,000,000 cu.

CHANNELERS AT WORK—AT LEFT, STA. 316+25—AT RIGHT, STA. 419+00, SHOWING TRAVELLING SMITHY MOUNTED ON TRUCKS

TWO VIEWS SHOWING CHANNEL CUT—AT LEFT, STA. 443+00, LOOKING WEST—AT RIGHT, STA. 448+00

yds. of rock; and from the river section, 2,000,000 cu. yds., mostly earth. These figures include the work already done.

The heavy rock fill section across the Whirlpool gully, illustrated on page 250 by the section at Sta. 335+00, is in an advanced stage of construction, approximately 50% of the rock being already in place. Behind the rock fill the whole of the gully is being backfilled with earth to the extent of 1,500,000 cu. yds., 80% of which is now in place. Each rock fill flanking the canal at this point has the following dimensions: Length at top, 650 ft.; length at base, 350 ft.; width at top, 20 ft.; width at base, 160 ft. Between these

JORDAN SPREADER PUSHING BACK DUMPED EARTH AT ST. DAVID'S DISPOSAL AREA

rock fills the base of the canal section is backfilled with rock to a depth of 8 ft.

Incidentally it may be mentioned that the filling of the Whirlpool gully and its offshoots will reclaim a considerable tract of land that will ultimately be of great value for factory sites.

The power-house site, which is at the foot of the steep cliff just above the Lewiston bridge, was difficult of access. An electric shovel is now cutting its way from Queenston to the power-house site, along the bank of the river, about ft. above normal water level. Besides cutting its own , the shovel is doing the necessary grading for the construction railway, which will run right into the power-house site.

As can be seen from the sketch on page 255, this construction railway connects with the Michigan Central, use of a portion of the International Railway's pretracks and also of the new tracks that will be built by International Railway. This new route will give the ternational Railway a better approach, having a much less dangerous grade, to the Queenston dock, and will also permit the use of the large gully south of the dock as a dump for the material excavated from the power-house site.

The construction railway has been completed from the forebay to Sta. 170, and to the disposal area at St. David's. It has also been constructed from the Welland river to Sta. 40, and will soon be connected between Sta. 40 and Sta. 170. Switching arrangements have been completed at the Welland river for interchanging traffic with the Michigan Central's Welland-to-Niagara Falls line.

The channel south of Hog Island, where the intake will be constructed, is being widened and deepened, and this work is practically completed. The dredge is now working in the Welland river digging out the piers of the old highway bridge. The dredged material is floated down the Niagara river on scows and dumped. An "unloader" is moored to a stone-filled crib in the river, and the scows are controlled by the steel wire cable running from the drum of this "unloader," with the result that only two tugs are required to guide each loaded scow and "spot" it over the dumping site; moreover, the chance of a scow breaking loose from the tugs and going over the Falls is largely obviated.

TRAIN UNLOADING AT ST. DAVID'S DISPOSAL AREA—NOTE LOW-LYING GROUNDS AT LEFT, PROVIDING DUMP 200 ACRES IN EXTENT

The towers for the cableway, which is being used to a great extent in the widening of the Welland river, run on standard gauge tracks. Each tower has two tracks at 40-ft. centres and hauls itself along by its own motor by means of a line to a deadman. No work has been done as yet on the control works at the junction of the canal with the Welland river, nor in connection with the intake itself.

Prof. R. W. Angus, of the University of Toronto, has been engaged this summer and last summer in experiments with hydraulic similarity models at Dufferin Islands, near the Ontario Power Co.'s intake in the Niagara river; and the Chippawa intake, which will extend into the river from Hog Island, as roughly indicated on the plan on page 251, will be built in accordance with the results of these experiments.

It is likely that this structure will be of concrete, so designed as to be able to take the water from the bottom of the river whenever desirable in order to avoid ice.

The central works near the junction of the canal and the Welland river will consist mainly of Stoney sluices, so arranged that the canal can be drawn off at any time in case of emergency.

Experiments are now being conducted regarding the relative efficiencies of concrete and gunite (the sand-cement

¾-Yd. Shovel at the G.T.R. and M.C.R. Junction

product shot by cement-guns) linings for the portions of the canal that are in rock. It has not yet been fully decided by what method, or to what extent, the canal will be lined. Wherever the canal is in rock, however, it will be lined to a height of at least 30 ft. from the bottom, and in the earth sections it will be lined everywhere to El. 563. At the Welland river for example, the bottom of the canal is approximately at El. 523, so the sides there will be lined for a height of 40 ft.

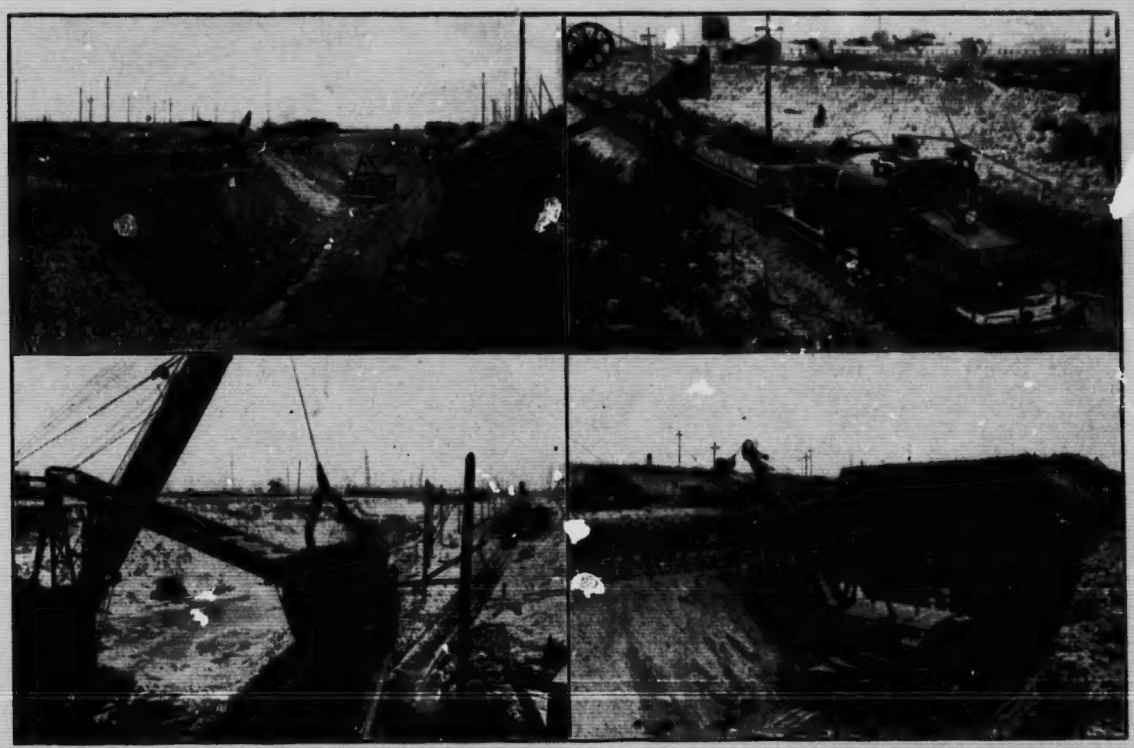
Over 130 buildings have been built, moved or repaired

4½-Yd. Shovel in Rock at the Forebay

during the course of construction to date. Most of the new buildings are of a temporary nature.

Among other work which is being carried out by the commission to remedy the changes in the landscape that are being caused by the power canal, is the construction of several bridges.

A reinforced concrete arch, 86-ft. span, to carry the Niagara, St. Catharines & Thorold Railway across the canal,



Four Views of One of the 8-Yd. Shovels Working in Earth—Top Left Photo Shows Some Rip Rap in Place—Top Right, Train Being Loaded at Sta. 346+81—Bottom Left, Working South of the Wabash R'y—Bottom Right, Working Against a High Face at Sta. 346+81

CRUSHER PLANT—PRIMARY TRAYLOR CRUSHER AT LEFT, GYRATORIES IN CENTRE, SCREENS ABOUT TO BE ERECTED AT RIGHT—CAPACITY, 3,500 CU. YDS. DAILY

is practically completed. An arch of 100 ft. span has been built to carry the Wabash Railway. Where the Grand Trunk Railway and the Michigan Central Railway cross the line of the canal, the tracks are only about 90 ft. apart; therefore, with a view to future requirements, the skew arches that will carry these railways across the canal will be carried though, making one continuous structure and providing ample room for additional tracks. These two railways have been temporarily diverted during the con-

THE BETHLEHEM STEEL CO.'S SPECIAL ARTILLERY TRUCK WAS REQUIRED TO CARRY THE MASSIVE PARTS OF THE TRAYLOR JAW CRUSHER

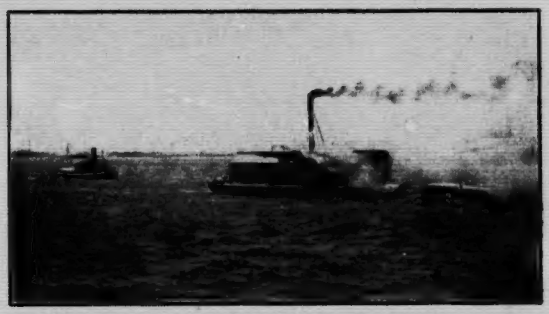
struction of this bridge, and work has begun on the foundations.

The N. St. C. & T. R'y bridge involved the diversion of the existing single track to one side of the bridge site and the construction of a double track reinforced concrete arch with 86 ft. span, having a rise of 25 ft. This arch was designed for Coopers' E-60 loading, and contains approximately 3,500 cu. yds. of concrete and over 90 tons of steel. The depth from base of rail to foundations is 52 ft. Lackawanna sheet piling was driven around the abutments, cofferdams were unwatered and material excavated to required depth after a great deal of trouble was caused by the satura-

DUMPING ROCK FROM TRESTLE FOR FILL AT THE WHIRLPOOL GULLY

tion of the surrounding subsoil. The arch was completed and traffic restored to the original alignment last December. A temporary timber trestle was designed to carry the N. St. C. & T. R'y line over the construction railway tracks, which are in the canal prism and parallel to the centre line of the canal.

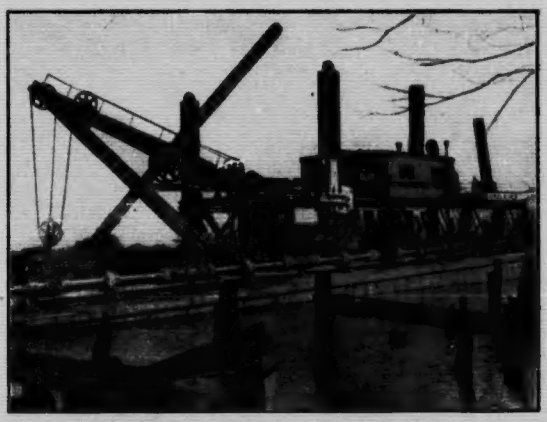
The Wabash line was diverted on a timber trestle over 40 ft. high, extending across the previously excavated canal section. The excavation of the canal prism thus provided natural drainage for the foundations for the 100-ft. reinforced concrete arch. This arch differs in design from the N. St. C. & T. R'y arch, as the Wabash arch has straight wing gravity walls instead of the reinforced cantilever type



SCOW-LOWERING AND REHAULING OUTFIT AT WORK ON THE NIAGARA RIVER

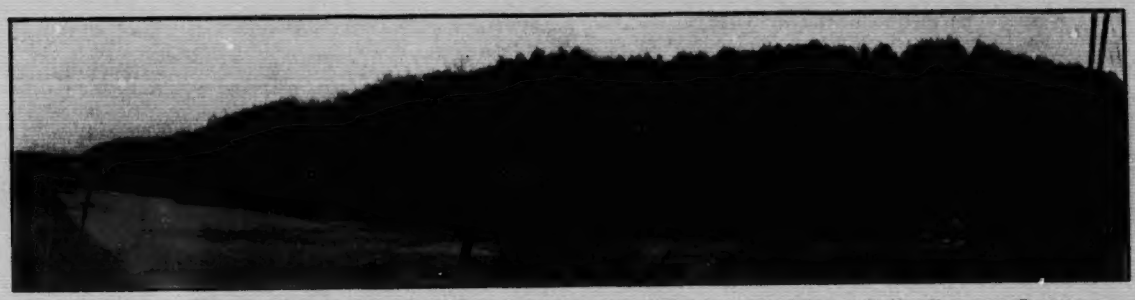
used in the other arch. There are approximately 3,000 yds. of concrete and 65 tons of reinforcing steel in the construction. The structure provides for two tracks, spaced 13 ft. centres, which will take care of the requirements of that railway for many years. The main line tracks of the Wabash are also carried over the construction railway by means of a temporary trestle.

A 3-track trestle about 400 ft. long has been built for the diversion of the main line of the Grand Trunk and the branch line of the Michigan Central. Upon completion of the



DREDGE AT WORK ON THE WELLAND RIVER

outside portions of the new arch, it is intended to re-divert traffic to the present alignment. The new structure will be a reinforced concrete arch, having a span of 72 ft. and rise of 20 ft. and involving the placing of 10,000 cubic yards of concrete and 325 tons of steel. It will provide room for 10 tracks. In the restoration of the G.T.R. and M.C.R. to the original alignment, a temporary timber trestle will carry the tracks over the construction railway. The trestles for diversion and relocation of these railways involve the use of over 300,000 ft. of timber.



VIEW FROM EAST END OF LEWISTON BRIDGE, SHOWING NATURE OF THE CLIFF ALONG WHICH ⅜-YD. ELECTRIC SHOVEL IS CUTTING PATH FOR CONSTRUCTION RAILWAY, 30 FT. ABOVE WATER LEVEL

The completion of these three arches will greatly assist the progress of excavation, as the equipment will then be free to move to any point, and the innumerable delays occasioned by the railways will be entirely eliminated, and the output of the excavating equipment will not be hampered in its course to the disposal area.

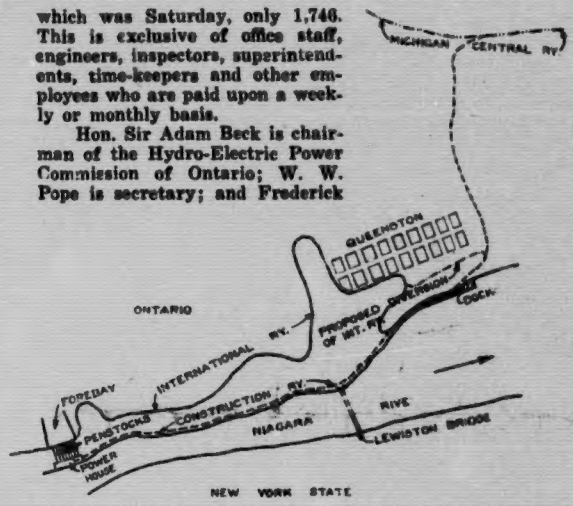
At Lundy's Lane, the highway is now being diverted to the north to a point where the construction railway is at the same elevation as the original ground line. This is preparatory to making the cut at Lundy's Lane, after which a highway bridge will probably be constructed across the canal at a point most favorable in respect to grades and detours.

Two new bridges must be built across the Welland river on account of the enlargement of that stream. These bridges will be of steel, and excavation is now in progress for their foundations. The Michigan Central Railway bridge will be a swing span, and the highway bridge will be a bascule, with a 90-ft. leaf.

LOOKING ACROSS NIAGARA RIVER FROM HOG ISLAND—THE INTAKE WILL EXTEND INTO THE RIVER FROM THIS ISLAND

The number of men on the daily pay-roll varies considerably; for instance, on August 14th, 1919, exactly 1,884 men reported for work; the following day, 1,905; on August 16th, which was Saturday, only 1,746. This is exclusive of office staff, engineers, inspectors, superintendents, time-keepers and other employees who are paid upon a weekly or monthly basis.

Hon. Sir Adam Beck is chairman of the Hydro-Electric Power Commission of Ontario; W. W. Pope is secretary; and Frederick A. Gaby is chief engineer. The design and construction of the Queenston-Chippawa project, with the exception of the electrical work, are under the direction of the Commission's hydraulic department, of which Henry G. Acres is the hydraulic engineer; Thos. H. Hogg, assistant hydraulic engineer; and Max V. Sauer, designing engineer.



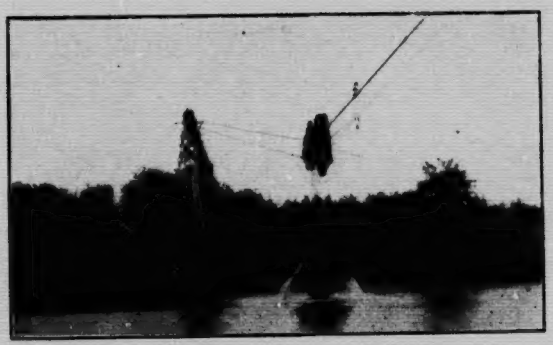
PLAN SHOWING ROUTE OF QUEENSTON CONSTRUCTION RAILWAY NOW BEING GRADED, AND PROPOSED DIVERSON OF INTERNATIONAL RAILWAY'S LINE TO THE DOCK

E. T. Brandon is the electrical engineer of the Commission; and Arthur H. Hull, assistant electrical engineer.

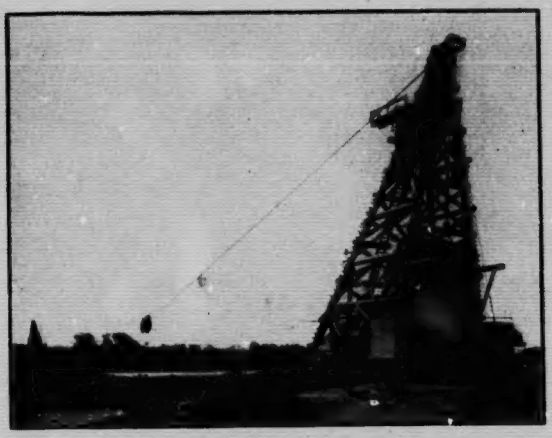
At Niagara Falls there is a large staff under the direction of J. B. Goodwin, works engineer, and of George Angell, general superintendent of construction. A. C. D. Blanchard

LOOKING UP THE WELLAND RIVER, HOG ISLAND AT THE RIGHT—BEFORE AND AFTER WIDENING THE INTAKE CHANNEL OF THE CANALIZED RIVER SECTION

is chief field engineer; Francis W. Clark, division engineer in charge of the intake, river section and canal; and Walter Jackson, division engineer in charge of the forebay and power-house. The resident engineers are W. S. Orr, Division No. 1 (river section); C. H. McDougall, Division No. 2 (Welland river to Sta. 235); and George H. Lowry, Division No. 3 (Sta. 235 to Sta. 428). Channel Anderson is superintendent of Division No. 1; F. W. Scriven, of Division No. 3; and W. L. LeRoy, of Division No. 4 (forebay, power-house and Queenston construction railway). Harold L. Bucke is superintendent of railway construction; R. T. Gent, plant engineer; P. Reid, mechanical superintendent; and F. F. Cooper, chief clerk.



DREDGING THE WELLAND RIVER—A BUCKETFUL



THE CABLEWAY EXCAVATOR HAS AN 800 FT. SPAN

Editorial from The Canadian Engineer, August 28th, 1919, issue.

MODERN MACHINERY SUPERSEDING LABOR

POWER-DRIVEN machinery is being manufactured with ever-increasing capacities, reducing labor costs (in hours, at least, if not always in dollars, owing to increasing wages) per unit of work done, permitting larger jobs to be completed within the same time, reducing the important item of "interest during construction," and providing the engineer with more powerful weapons with which to overcome obstacles and to harness the forces of nature.

A striking example of the utility of big plant for big work, is the Queenston-Chippawa power canal, the progress of which is described in this issue. The amount of earth and rock being handled by a comparatively small force, constitutes a record previously unknown in the construction world. The daily removal of over 20,000 cu. yds. of earth and rock, in addition to the accomplishment of a great amount of other work such as railroad construction, bridge-building, etc., all with an average daily payroll of considerably less than 2,000 men, is a feat that could not have been performed a few years ago without expenditures for plant that would have been enormously out of proportion to the value of the work being done. This feat has been made possible by the development of economical machines that are giants in comparison with the machines of a decade ago.

The construction undertakings of the past were not large enough, with but few exceptions, to permit of huge investments in construction plant, and in many cases where unusually powerful equipment could have been used, it was not designed owing to the recognized impossibility of finding a market for it after the work had been completed. To-day there is almost invariably a market for all construction equipment that is in good condition, regardless of its size.

The power-shovel manufacturers and the builders of large crushers are, in a great measure, responsible for the improved methods of handling rock, and they predict that within a very short time they will be selling 10-yd. shovels, 84-in. by 120-in. jaw crushers and 84-in. gyratory crushers. On the Queenston-Chippawa job there are 5-yd. shovels and a 60-in. by 84-in. jaw crusher. Since this job was started, 66-in. by 86-in. jaw crushers and 60-in. gyratory crushers have been built and placed in successful operation.

The evolution of huge shovels and crushers has been slow but steady and sure. Sizes of crushers built thirty years ago, and at that time considered large, to-day are not manufactured except for laboratory work, as their operation is no longer economical.